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present concisely the essential steps in the processes under consideration. These, with other features, make the book very accessible and helpful. It might here be suggested that the diagrams would be improved by larger index characters, and that somewhere a concise index to the various terminologies scattered through the chapters would make them more available.

It is not to be hoped that in a book of this character there should be an absence of errors, although in this instance they are not so numerous as usual. Certainly they do not render the text as a whole unsafe for the unguided beginner. Because of the merit of the book in general and its obvious adaptability to the present needs of a great variety of people, it is particularly important to reduce errors of all sorts to a minimum. Undoubtedly, the cordial invitation of the author for assistance in eliminating these will be met with a helpful response by his fellow workers. Here it should suffice to speak of only more general features needing attention.

Owing to the fact that the book will most largely be used by those generally unfamiliar with cytology, and having varied approaches to it, there is need for the greatest clearness in distinguishing between the different categories of objects and conditions described. This is not always done and there is sometimes confusion between gene and character, and between the valence of the elements in the chromosome complex. In the effort to simplify the presentation of the maturation phenomena in some of the diagrams, only one mitosis is shown. While this displays clearly one of the important conditions of meiosis it entirely neglects another, viz., the essential unity of the two maturation mitoses as a process. This is further emphasized by the consistent use of the terms "heterotypic" and "homotypic." Enough evidence has been presented to show beyond question that the first maturation mitosis is not necessarily a reduction division as the terms imply. It is necessary only to recall the behavior of the sex chromosomes in the Hemiptera and the "selected chromosomes" in Phrynotittix, as described by Wenrich, to demonstrate this. There is something in meiosis besides a reduction division and an ordinary equation division. It is important to show clearly that meiosis is a unique phenomenon.

Doubtless, there are other instances of similar differences in point of view between author and reviewer which might be used to illustrate the present status of opinion in cytology, and the degree of adaptability of the text of Professor Sharp as an introduction to the subject. What has been given will, however, suffice to show that the existing differences of opinion are not extreme, that they are fairly presented in the text, and that in their exposition, a work has been produced that will serve to extend the usefulness and influence of cytology greatly. It is not venturing far to predict that the "Introduction to Cytology" will take its place as a worthy member of the very successful series of which it is a part.

C. E. McCLUNG

SPECIAL ARTICLES

CONTINUOUS RENEWAL OF NUTRIENT SOLUTION FOR PLANTS IN WATER-CULTURES

IN the experimental study of the salt nutrition of plants, it is of course very important that all the influential features of the culture media be definitely known. The initial composition of a mixed salt solution employed for water-cultures may be known with a marked degree of accuracy, but the chemical make-up of such a nutrient solution begins to be altered immediately after the introduction of the plants; materials, of course, move from the roots into the solution, as well as in the opposite direction, and the solution soon becomes significantly different from what it originally was. Since there is no feasible way by which all the various kinds and rates of alteration may be adequately determined, the culture solutions must be renewed from time to time if the growth of the plants is to be correlated with known chemical conditions surrounding their roots, and renewal must be frequent enough to allow these unknown alterations to be regarded as uninfluential.

How frequently water-culture solutions should be renewed is always a difficult question. With small culture vessels, with large plants, or with many plants in a vessel, it is

clear that renewal ought to be more frequent than with larger vessels, smaller plants, and so forth. The labor involved is generally a serious consideration also. Whether solutions were renewed frequently enough, in particular experiments, to allow growth to be correlated with the characteristics of the solutions as these were originally prepared has been a subject of discussion from time to time. To answer this question for any experiment, a number of different renewal frequencies may be simultaneously tested, to determine how often the solutions must be changed in order that no difference in growth may result with still more frequent renewal.

A consideration of this question, together with the amount of labor involved in renewing a large series of solutions, leads obviously to the suggestion that the solution might be made to flow continuously through the culture vessel, the inflow being of known composition and the outflow being discarded. If the rate of flow is rapid enough, the discarded solution will not be significantly different from the inflow, and the roots may be said to have been in a known set of chemical surroundings throughout the culture period. Several rates of flow should be simultaneously tested, at least in a preliminary way, in order to make sure that the data studied shall have been secured with a sufficiently rapid rate. By employing continuous flow, the labor of renewing solutions would be practically avoided, since the apparatus would operate continuously without alteration, aside from the preparation of solutions and their introduction into the apparatus from time to time. The apparatus should automatically maintain any desired rate of flow through the culture vessel.

The need of an apparatus for continuous flow has become increasingly evident throughout the recent development (begun by Schreiner and Skinner, and Tottingham) of water-culture experimentation by means of logically complete series of salt combinations. A preliminary step was taken when Trelease and Free,[1] working in this laboratory in 1916, concluded that Shive's nutrient solution R5C2 (1.75 atm.) gave better growth the more frequently the solution was renewed, a continuous flow giving better growth than did daily renewal. Although, with the gradually improving technique of the water-culture method, many workers[2] have doubtless appreciated the desirability of continuous flow, constantly flowing solutions appear not to have been subjected to any further tests thus far recorded in the literature.[3] It is interesting to note, however, that the logical need of continuously renewed culture solutions was clearly stated by Stiles.[4] when he wrote: "In no case has a constantly renewed culture solution been employed. Thus the ratio of the various constituents was probably constantly changing throughout the experiments, and instead of being a constant factor was an unknown and varying one." Also, Duggar[5] mentioned the need of frequently renewed or continuously flowing solutions, but concluded that any operation involving continuous flow "would be impracticable in most of our experimental work."

This paper is planned to emphasize still further the need of flowing solutions and to present a brief description of an arrangement for securing them.

The accompanying diagram shows the main features of the apparatus, which consists

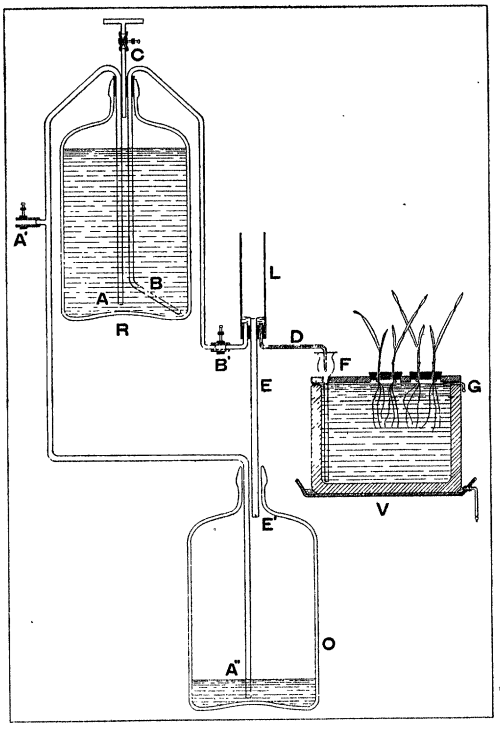
[1] Trelease, S. F., and E. E. Free: "The effect of the renewal of the culture solutions on the growth of young wheat plants in water-cultures. *Johns Hopkins Univ. Circ.*, N. S., No. 3, March, 1917, pp. 227 and 228.

[2] Conner, S. D., and O. H. Sears: "Aluminum salts and acids at varying hydrogen-ion concentrations, in relation to plant growth in water cultures. *Soil Science*, 13: 23-33, 1922, p. 27.

[3] In 1865 Nobbe flowed solution into a vessel in which plants were growing, but he seems not to have tried to control the rate of flow.

[4] Stiles, Walter: "On the interpretation of the results of water culture experiments." *Annal. Bot.*, 30: 427-436, 1916.

[5] Duggar, B. M., "Hydrogen ion concentration and the composition of nutrient solutions in relation to the growth of seed plants. *Annals Missouri Bot. Gard.*, 7: 1-49, 1920, p. 43.—*Idem.*, "The use of 'insoluble' salts in balanced solutions for seed plants." *Ibid.*, 7: 307-327, 1920, p. 308.



essentially of four parts: the upper reservoir (R), the constant-level tank (L), the lower reservoir (O), and the culture vessel (V). The upper reservoir (R) holds 5 gallons of solution when full, and acts like a constant-pressure aspirator, drawing air through tube A'A and delivering solution through the siphon tube (B), to the constant-level tank (L). The latter is a piece of 5-cm. glass tubing closed below by means of a rubber stopper with three tubes, B, E, and D. Solution flows into the tank through tube B, at a rate somewhat greater than is required for the culture vessel, and the excess passes into the lower reservoir (O), through the tube E, the tank level being automatically maintained at the top of the last-mentioned tube. The rate of flow through B is adjusted by adjusting the height of the lower end of tube A with reference to the upper end of E. Solution flows at a practically constant rate from the constant-level tank, through a small-bore delivery tube (D), and drips regularly into the thistle-tube receiver (F) of the culture vessel. The desired rate of flow through tube D is secured by adjusting the height of the upper end of E with reference to the lower end of D—that is, by adjusting the "head" maintained by the constant-level device.

The culture vessel shown is a 3-gallon, glazed earthenware "butter" jar, covered by a paraffined top, of wood, cement or plaster of Paris, with eight large openings, in which are set the flat cork stoppers that support the plants. There are five wheat seedlings in each stopper, forty seedlings in all. The top is supported about 4 mm. above the top of the jar. The receiver tube (F) has a waxed-paper cover, through which passes the delivery tube. Tube F extends nearly to the bottom of the culture vessel, and solution flows into the latter, keeping it filled to the brim and overflowing at the top, through the waste tube (G).

Solution that collects in the lower reservoir (O) has not been vitiated in any way by its passage through the constant-level tank, and it is raised to the upper reservoir (R) from time to time, together with additions of newly prepared solution. This transfer is effected through the tube A"A, by closing cocks A' and B' and applying suction at C (by means of an ordinary filter pump). When the transfer is completed, cock C is closed and cocks A' and B' are opened.

The reservoirs should be covered with opaque paper, to exclude nearly all light and retard the development of algæ.

The constant level device and the lower reservoir may be dispensed with entirely if the temperature of the upper reservoir can be maintained practically constant, or if only an approximately constant rate of delivery of solution is desired. In this case, tube B would discharge directly into the receiver tube (F). This simpler apparatus is the one employed by Trelease and Free.

Doubtless, the apparatus here described may be modified in many ways, to suit the facilities and requirements of different experimenters; but this form operates very satisfactorily. As thus far used, a series of five are delivering five different solutions to their respective culture vessels at a rate of about 16 liters a day, which amounts to 400 c.c. a day for each of the forty plants in the culture. With liter jars, five plants per culture, and solution renewal every three and one half days (as in the plan published by the National Research

Council Committee on Salt Requirements of Plants) each plant would receive 57 c.c. per day.

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MARCH 23, 1922

NOTE ON THE SYNTHESIS OF ETHYL BUTYRATE IN EGG SECRETION

IN our analyses of egg secretion, Miss Woodward[1] and I[2] have isolated an enzyme of the lipase group. The material, precipitated as a white powder, is soluble in both sea-water and fresh. In the presence of this "lipolysin," droplets of egg fat decrease in diameter while the hydrolysis of other neutral fats and the cleavage of ethyl butyrate are measurably accelerated.[3]

Since lipolysin is a parthenogenetic agent;[1, 4] since the unmodified egg-secretions also have parthenogenetic[5] and lipolytic[3] powers; and finally, since eggs with secretions removed by brief exposure to charcoal are completely sterile,[3] it seems likely that lipolysis plays some rôle in the normal initiation of development.[1] However, the evidence that egg-secretions have these powers is still incomplete. It has not been reported whether, under conditions significant for fertilization theory, the effects already observed are reversible.

Accordingly, I prepared egg-secretion as free from contamination as possible and used chloroform to inhibit bacterial action. To 10 or 15 c.c. of this, I then added, in one set of experiments, .5 c.c. of absolute ethyl alcohol; in another, 5 c.c. of 2N. Butyric acid was introduced last of all. The final concentration of the acid was roughly .25 N. and .4 N.

The acidity of the systems was, of course, immediately reduced by the salts present in both the secretion and the sea-water. Under the circumstances then, the loss in total acidity has no meaning for the problem in hand. Only differences are important, and, if in the presence of egg-secretion, a portion of the butyric acid is transformed into butyric ester, the tubes in which this occurs should require less alkali than the controls in order to reach the turning point, P_{H_7}, of di-brom-thymol-sulpho-phthalein.

The differences of acidity actually found between 10 c.c. of control and 10 c.c. of digest, in one case, after 40 minutes at 20° C., amounted to .8 c.c. NaOH N/20; in another, after an hour, to 2.4 c.c. NaOH N/20, in both instances, in favor of the controls.

Absolutely, these discrepancies are small, but even greater differences might fail to be convincing, for conceivably, the organic constituents of the secretion, still largely unknown, might in some way destroy or otherwise remove butyric acid from the reaction system. Fortunately, however, ethyl butyrate has an odor so penetrating and characteristic that even minute traces can be unmistakably detected. By this delicate test, the ester, regularly absent from the controls, was present in noticeable quantities in the digests with secretion and was easily recognized by others not familiar with the experiments. For eighteen hours the ester smell continued to grow in intensity.

On the basis of these results, I attribute to egg-exudate the power to accelerate the synthesis of ethyl butyrate. This is neither more nor less than might be expected since the same exudate also accelerates the corresponding hydrolysis.

OTTO GLASER
AMHERST COLLEGE,
FEBRUARY 2, 1922

1 Woodward: *J. Exp. Zool.*, Vol 26, pp. 459-501.
2 Glaser: *Am. Nat.*, Vol. LV, pp. 368-373.
3 Glaser: *Biol. Bull.*, Vol. XLI, pp. 63-72.
4 Woodward: *Biol. Bull.*, Vol. XLI, pp. 276-279.
5 Glaser: *Biol. Bull.*, Vol. XXVI, pp. 387-409.

NATIONAL ACADEMY OF SCIENCES

At the annual meeting of the National Academy of Sciences held in the U. S. National Museum, Washington, on April 24, 25 and 26, papers were presented as follows:

The new building of the National Academy and the National Research Council: C. D. WALCOTT, President of the Academy. The erection of a magnificent building, costing $1,300,000, as the home of the National Academy of Sciences and the National Research Council, will shortly be begun on the square bounded by B and C streets, 21st and 22d streets, northwest, Washington. The